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Technical Attachment

Tornado Risk in the Southeast United States

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Abstract

The Southeast is more vulnerable to the devastating effects of tornadoes than any other part of the United States. This is due primarily to building integrity, because a significant percentage of the dwellings are mobile homes, and few basement foundations are found. Analysis of data from 1970-1999 shows that six out of ten states with the highest tornado casualties are in the Southeast. Despite the relatively high number of tornado casualties in the Southeast, the frequency of significant tornadoes (F2 or greater) is actually higher in other parts of the country.

Several other factors contribute to any community's vulnerability to tornado damage, including population density, tornado frequency and the level of severe weather preparedness. Based on these factors several other locations of the country need to consider their vulnerability to tornadoes; in particular, areas of high population density with relatively low frequency of significant tornado occurrence.

Introduction

The notion of a "tornado alley" is based on that part of the United States where significant tornadoes (F2 or greater) most frequently occur. A climatological basis for tornado alley places this region across the central and southern Plains (Concannon *et al.* 2000).

Emergency managers can more appropriately design a preparedness plan by knowing where significant tornadoes occur most frequently. In tornado alley, severe storm spotters are more readily organized, warning dissemination systems tend to be a priority, and there is an increase in awareness to develop partnerships between media, emergency management, and the National Weather Service. But understanding a region's safety risk from tornadoes should not be determined solely by frequency. Rather, several other elements must be considered, including severe weather preparedness, building construction, casualties, and population density. All of these were considered in this study of tornado risk in the southeast U.S.

Data

We used tornado data for a 30-year period from 1970-1999 to assess tornado risk. The data were obtained from Grazulis (1993) and the NCEP Storm Prediction Center's Web site. Only the last thirty years of tornado data were chosen because many of the elements that influence tornado risk

prior to this period have changed substantially. For example, warning dissemination and lead-time have improved significantly (Fig. 1).

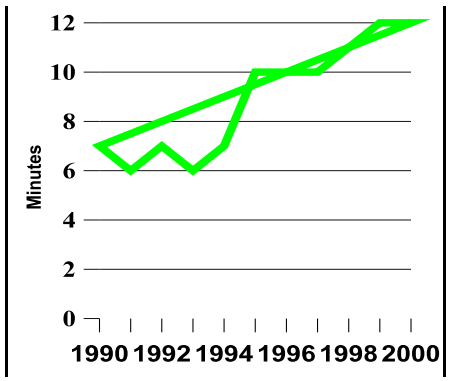

Figure 1. Average warning lead-time for tornadoes nationwide.

This study used mobile home demographics and population statistics from the 1990 Census Bureau Report to measure building construction and population density.

Objectively measuring a state's severe weather preparedness is difficult and problematic at best. Several aspects include: number of trained severe weather spotters, number of outdoor warning systems, NOAA Weather Radio coverage, community participation in severe weather awareness week activities sponsored by the NWS and emergency management, and number of StormReady communities. If a state is located in or near tornado alley, then typically there is strong participation in these activities and programs. Such participation leads to a high degree of severe weather preparedness. For the purpose of this study severe weather preparedness will not be quantified, however; we presume it to be directly related to the frequency of significant tornadoes within each state.

Casualties per year

One method of examining tornado risk is by looking at tornado casualties per year. For the purpose of this study casualties include both deaths and injuries. Over the 30-year period from 1970-1999 no state registered more tornado casualties per year than Texas (Fig. 2).

Table 1 shows that eight of the top ten states for tornado casualties per year are located in the south-central and southeast United States. Table 2 is a ranking of 30-year tornado casualties per square mile. Several small northeast states rank high, however, the majority of states in the top 15 are in the South.

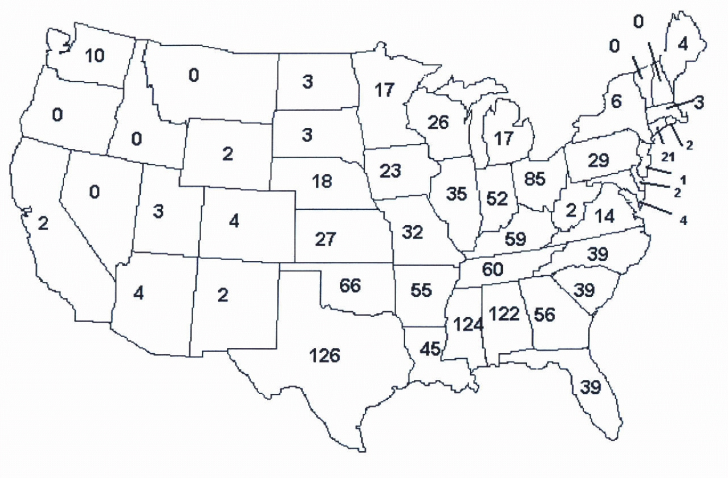

Figure 2. Tornado casualties per year by state (1970-1999).

Table 1. Top ten states for tornado casualties per year in the United States (1970-1999).

1. Texas	126	6. Tennessee	60
2. Mississippi	124	7. Kentucky	59
3. Alabama	122	8. Georgia	56
4. Ohio	85	9. Arkansas	55
5. Oklahoma	66	10. Indiana	52

Table 2. Top fifteen states for tornado casualties per square mile (1970-1999).

1. Connecticut	6. Indiana	11. Louisiana
2. Mississippi	7. Tennessee	12. Georgia
3. Alabama	8. South Carolina	13. Oklahoma
4. Ohio	9. Delaware	14. North Carolina
5. Kentucky	10. Arkansas	15. Rhode Island

Building Construction

One cause for such high tornado casualties in the southern states is the nature of building construction. According to Brooks and Doswell (2001) the current death rate for mobile home residents is nearly equal to what the overall national rate was prior to 1925, and more importantly, is about 20 times the rate of residents in permanently built homes. Table 3, from the 1990 Census Report, lists the top 15 states for the percentage of mobile homes, compared to total housing. The Rocky Mountain states and southern states emerge as regions with the highest percentage of mobile homes.

Table 3. Percentage of mobile homes compared to total housing (1990 Census Report).

1. New Mexico/South Carolina	17.8%
3. Wyoming	17.6%
4. Arizona	16.5%
5. West Virginia	16.4%
6. Montana	16.2%
7. North Carolina	16.1%
8. Mississippi	14.8%
9. Idaho/Nevada	14.6%
11. Alabama	14.3%
12. Arkansas	14.1%
13. Florida	13.4%
14. Kentucky	13.2%
15. Delaware/Louisiana	12.7%

Population Density and Community Preparedness

Table 4 ranks the top twenty states for casualties per tornado. One reason for such a high rate of casualties per tornado in states such as Connecticut, Rhode Island and Pennsylvania is the combination of low tornado frequency and a high population density. A high population density naturally increases the chance for each tornado to inflict casualties drastically (Table 5), but in addition, a lower frequency of tornadoes may tend to contribute to lower community awareness and thus preparedness. Indeed, in Washington, where the rate of casualties per tornado ranks third nationally, the statistic is inflated due to a low tornado frequency. Although tornadoes are rare in Washington and Connecticut, when they do strike a populated area the potential for casualties is higher than in a region where a high frequency of tornadoes contributes to greater community preparedness.

Table 4. Casualties per tornado (1970-1999).

1. Connecticut	16.5	11. Georgia	2.6
2. Alabama	5.4	12. Indiana	2.4
3. Washington	5.3	13. Pennsylvania	2.4
4. Kentucky	5.1	14. North Carolina	2.3

5. Mississippi	4.4	15. Virginia	1.9
6. Tennessee	4.3	16. Massachusetts	1.6
7. Ohio	4.2	17. Oklahoma	1.6
8. South Carolina	3.5	18. Delaware	1.5
9. Rhode Island	2.9	19. Louisiana	1.5
10. Arkansas	2.8	20. Utah	1.4

Table 5. The ten most densely populated states (1990 Census Report).

1. New Jersey	6. New York
2. Rhode Island	7. Delaware
3. Massachusetts	8. Pennsylvania
4. Connecticut	9. Ohio
5. Maryland	10. Florida

Tornado alley is located in a relatively sparsely populated region of the United States. Table 6 ranks the ratio of casualties to population density. When casualties are normalized for population density the less populated states in the Great Plains emerge. These states are prone to a high frequency of significant tornadoes and likely possess a high degree of community preparedness, but because of their low population density the effects of these tornadoes are not as notable as in the Southeast.

Table 6. Tornado casualties normalized for population density.

1. Mississippi	6. Kansas	11. Iowa	16. North Dakota
2. Texas	7. Nebraska	12. Louisiana	17. Indiana
3. Alabama	8. Kentucky	13. Wyoming	18. South Carolina
4. Oklahoma	9. Tennessee	14. Missouri	19. Ohio
5. Arkansas	10. Georgia	15. South Dakota	20. Minnesota

Frequency of Significant Tornadoes

Tornadoes that produce F2 damage or greater are of concern to emergency management officials due to their potential to cause significant loss of life and property. States with a high frequency of these storms naturally have a greater risk, without regard to building construction, population density or warning preparedness. Table 7 ranks the top ten states for significant tornadoes. Most of these states comprise our traditional concept of tornado alley.

Table 7. Average number of tornadoes of intensity F2 or greater per year.

1. Texas	27	6. Kansas	9.3
2. Oklahoma	14	7. Arkansas	8.5
3. Mississippi	12	8. Louisiana	8.4
4. Iowa	11	9. Illinois	8.1
5. Alabama	9.4	10. Indiana/Nebraska	7.6

Conclusion

Significant improvement has taken place in weather warnings and dissemination in the last thirty years. NOAA Weather Radio now covers approximately 90 percent of the United States population and implementation of the Emergency Alert System (EAS) in 1997 has strengthened warning dissemination over commercial radio and cable television. However, if casualty rates across the southern U.S. are to improve then consideration must be given to adequate storm sheltering. The significance of increasing warning lead-time is diminished if citizens do not have access to safe rooms, storm shelters or basements. The number of mobile homes is significantly higher and basement construction is much lower in the Southeast in comparison to the Great Plains and Ohio Valley states.

Emergency management in Arkansas has developed a program over the past several years to provide matching funds for their citizens who build storm shelters. In the aftermath of several killer tornadoes, citizens in Mississippi were able to build storm shelters with matching Federal Emergency Management Agency funds. These are just a few examples of facilitating the construction of storm shelters. Other measures may include zoning requirements for safe rooms and insurance rebates for the construction of safe rooms and storm shelters.

References

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